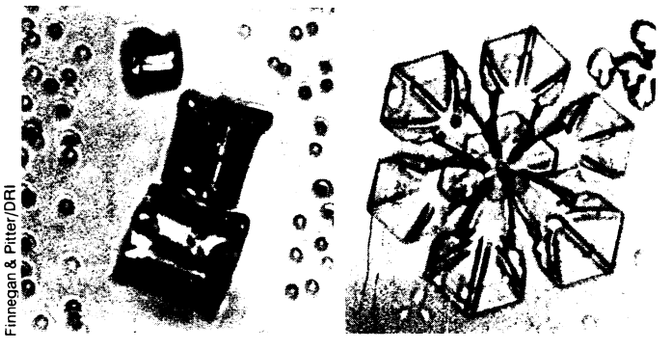
Snowflake growth puts on electrifying show

The symmetrical, lacy shapes of snowflakes dramatically illustrate how simple building blocks such as water molecules can settle into intricate geometric patterns. But the details of how this process occurs remain elusive. Now two researchers have discovered that minute traces of naturally occurring ionic salts, such as sodium chloride, play a crucial and hitherto largely unsuspected role in determining the symmetry, structure and chemistry of snowflakes and ice crystals.

William G. Finnegan and Richard L. Pitter of the Desert Research Institute in Reno, Nev., suggest that growing ice crystals can incorporate certain ions, leaving their oppositely charged partners behind in a thin liquid layer surrounding the ice core. In effect, a growing ice crystal acts like a battery, separating positive from negative ions to generate a potential difference across an ice-water interface amounting to 30 volts or more.



Finnegan & Pitter/DRI

Cylindrical ice crystals typically clump together to form T-shaped aggregates (left). A snowflake produced from a sodium chloride solution shows a distinctive pattern (right).

This charge-separation mechanism, which operates only while the ice crystal is growing, may not only determine a crystal's shape but also initiate important electrochemical reactions within ice crystals, leading to the production of chlorine and the reduction of carbon dioxide to formate ions. Such snowflake chemical reactions potentially furnish a natural source of chlorine and an unrecognized sink for carbon dioxide in the atmosphere.

"This is all new," Pitter says. "Most of what we have found is contrary to what the textbooks say." Finnegan and Pitter described their findings at a meeting this week in Washington, D.C., of the American Association of the Advancement of Science.

The initial impetus for this research came from studies of how and why ice crystals clump together. Researchers had observed that pairs of cylindrically shaped ice crystals often join point to center to form T-shaped aggregates. Moreover, in cloud-seeding experiments, an ionic salt such as silver iodide generally produces such aggregates much more readily than dry ice.

Using a cloud chamber, Finnegan and Pitter studied the formation of ice crystals from tiny, supercooled water droplets laced with trace amounts of different salts. By examining samples of the resulting crystals collected on microscope slides, they showed that a significant portion had joined together to produce T-shaped aggregates.

To explain their results, the researchers drew on research done in 1950, which demonstrated that charge separation by selective incorporation of ions into ice can occur during the freezing of bulk water when low concentrations of salts are present in the liquid. Finnegan and Pitter applied this mechanism to ice crystals of various shapes and reasoned that because a cylindrical ice crystal's tips and center would have opposite charges, such crystals would naturally join tip to center.

The same charge-separation mechanism may account for how a snowflake maintains its hexagonal symmetry while it grows, Finnegan and Pitter say. The electric charge left in the thin liquid film that typically surrounds a growing snowflake would continually redistribute itself so that growth proceeds more readily in certain preferred directions.

The researchers also discovered that the incorporation of particular ions influences crystal shapes in a consistent, reproducible fashion. For example, ice crystals grown in supercooled clouds of pure water at -16°C have branches with straight, parallel edges. Under the same conditions, clouds containing low concentrations of sodium chloride produce snowflakes with a distinctively different shape, in which each branch ends in a pattern resembling a duck's foot (see photo).

Recent experiments demonstrate that electrochemical reactions can occur within ice crystals as a result of charge separation, followed by the transfer of protons or electrons to neutralize the charge. Such reactions could play important roles in atmospheric chemistry, Finnegan says. "If we are correct, then it's very important to study the mechanisms of how these processes occur."

"Why do certain ions separate into ice? How does it happen?" Finnegan asks. "We don't have all the answers yet."

— I. Peterson

Insight proves key to marital therapy

The longest follow-up study to date comparing the effectiveness of two common approaches to marital therapy has yielded "quite unexpected" results, according to psychologist Douglas K. Snyder of Texas A&M University in College Station and his colleagues.

The study assessed the after-effects of "insight-oriented" therapy, which explores unconscious influences on marital problems, and "behavioral" therapy, which focuses on improving specific interpersonal skills.

Six months after married couples completed one or the other type of therapy, no differences in divorce rate or marital satisfaction showed up between the two groups, the researchers say. At that point, about two out of three couples who received either form of marital therapy reported happy marriages.

But the years that followed took a much greater toll on behaviorally treated couples, the team found. Ten of 26 couples divorced within four years of completing behavioral therapy, compared with only one of 29 couples who completed insight-oriented therapy. Although most still-married couples regarded their partnerships as stable, reports of marital discord emerged substantially more often in the behavioral therapy group.

The findings suggest that interpersonal skill training alone provides no more than a temporary band-aid for serious marital problems, the scientists assert in the February JOURNAL OF CONSULTING AND CLINICAL PSYCHOLOGY. Insight-oriented techniques help each partner to resolve largely unconscious emotional conflicts brought to the marriage from his or her family and relationship histories, the researchers say.

In previous follow-ups covering no more than two years, couples who participated in these two therapies showed no significant contrasts in divorce rate or in marital satisfaction.

Couples in Snyder's study received random assignments to behavioral or insight-oriented therapy and attended an average of 19 weekly sessions. Five experienced clinicians trained in both techniques provided the therapies.

Psychologist Neil S. Jacobson argues that insight-oriented marital therapy probably would show no long-term advantages over state-of-the-art behavioral therapy. Jacobson, of the University of Washington in Seattle, says behavioral therapy now includes strategies aimed at altering spouses' habitual, destructive patterns of thinking.

In Snyder's view, this approach still neglects preexisting emotional conflicts. Its long-term effectiveness remains unclear, he contends. *— B. Bower*